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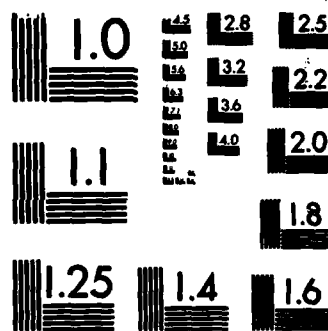FILMED
DTIC

cont.

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

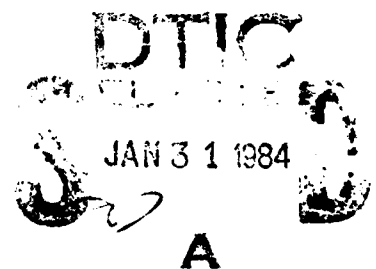# DEFENSE COMMUNICATIONS AGENCY

AD A137427

DEFENSE DATA NETWORK
X. 25 HOST INTERFACE
SPECIFICATION

DECEMBER 1983

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DEFENSE COMMUNICATIONS AGENCY

DEFENSE DATA NETWORK X. 25 HOST INTERFACE SPECIFICATION

DECEMBER 1983

PREPARED BY BBN COMMUNICATIONS CORPORATION

DDN

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ACKNOWLEDGEMENTS

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FIGURES

1 INTRODUCTION

This report specifies the attachment of an X.25 host to the
Defense Data Network (DDN). In particular, this report describes
specific options and features of CCITT Recommendation X.25 (1980)
and Federal Information Processing Standard (FIPS) 100/Federal
Standard (Fed. Std.) 1041 (July 1983) required of a host X.25
implementation to enable that host to communicate with a DDN X.25
Interface Message Processor ("IMP", the DDN packet switching
node). This report, in conjunction with FIPS 100/Fed. Std.
1041, should enable DDN host site managers and others planning to
attach a host by means of X.25, rather than the 1822 interface, *
to determine, first, whether or not the X.25 implementation of
the host in question is adequate for operation with DDN, and,
second, what options, parameter settings, etc. must or may be
selected for operation with DDN.

This report assumes that the reader is familiar with CCITT
Recommendation X.25 and FIPS 100/Fed. Std. 1041. A copy of FIPS
100/Fed. Std. 1041 is attached as Appendix C of this report.

In this document, the term "Administration" refers to the
Defense Communications Agency (DCA Code B610, Washington, D. C.
20305).

1.1 Background

1.1.1 X.25 and FIPS 100/Federal Standard 1041

The CCITT Recommendation X.25 describes the interface
between host computers (data terminal equipment, or DTEs) and
data circuit-terminating equipment (DCEs, which effect
communication with remote hosts over computer networks) for hosts
operating in the packet mode on public data networks. The X.25
interface standard is defined as three independent architectural
levels, following the Open Systems Interconnection (OSI)
Reference Model. The three levels are:

> Level 1: The PHYSICAL level of the connection. The
> physical, electrical, functional, and
> procedural characteristics to activate,

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* As used in this report, "1822 interface" refers to the
interface specified in Bolt Beranek and Newman Inc. (BBN) Report
No. 1822, "Specification for the Interconnection of a Host and an
IMP," revision of December 1981.

maintain, and deactivate the physical link between the DTE and the DCE.

Level 2: The LINK level of the connection. The link access procedure for data interchange across the link between the DTE and the DCE.

Level 3: The PACKET level of the connection. The packet format and control procedures for the exchange of packets containing control information and user data between the DTE and the DCE, and between the DTE and a remote DTE.

CCITT Recommendation X.25 contains many options and implementation choices. FIPS 100/Fed. Std. 1041, which specifies the general use of X.25 for the Federal Government, defines some of the choices left open in X.25. This document describes the X.25 interface to a particular network, DDN. Thus in several areas where X.25 allows a choice, a single choice appropriate for DDN is specified; in areas which X.25 leaves unspecified, addressing in particular, conventions are specified that are consistent with the overall architecture of DDN and the interoperability goals described below. The effect of this approach is to make DDN service available to hosts in a way that requires no changes to a host DTE implementation that is compliant with FIPS 100/Fed. Std. 1041 and CCITT Recommendation X.25. By implementing extensions described in this specification, a host will be able to take advantage of additional DDN features required in military networks, such as precedence and logical addressing.

The reader is referred to CCITT Recommendation X.25 and to FIPS 100/Fed. Std. 1041 for detailed information not provided in the body of this document.

1.1.2 X.25-to-X.25 and X.25-to-1822 Interoperability

A key goal of the DDN X.25 implementation is interoperability among all DDN subscribers. That is, effective communication should be possible, not only between subscribers attached to the DDN using identical vendor-supplied X.25 implementations, but between subscribers using different X.25 implementations, and between a subscriber using an X.25 interface to the DDN and a subscriber using an 1822 interface to the DDN. Achieving this goal of interoperability requires that all DDN

X.25 subscribers conform to this interface specification and
implement the DoD standard higher level protocols. True
interoperability among DDN hosts requires, in particular,
implementation of the DoD standard protocols TCP (Transmission
Control Protocol) and IP (Internet Protocol), as well as the
higher-level protocols which implement DDN standard services,
when such services are provided by the host: the Telnet Protocol
for character-oriented terminal support, the File Transfer
Protocol (FTP) for file movement between hosts, and the Simple
Mail Transfer Protocol (SMTP) for communication between
electronic mail service hosts.

The DDN X.25 DCE offers two types of service to X.25 DTEs:

1. DDN Standard X.25 Service, which, when used in
    conjunction with DoD standard protocols, provides
    interoperable communication between an X.25 DTE
    and other DDN hosts that also implement the DoD
    standard protocols, whether they are connected to
    DDN via the 1822 interface or via the X.25
    interface;

    and

2. DDN Basic · X.25 Service, which provides
    communication only between an X.25 DTE and other
    DDN X.25 DTEs implementing compatible higher-level
    protocols.

Section 2.1.2.1 of this report describes the conventions to
be used by a DTE to specify the type of service desired for each
X.25 virtual call. All DDN X.25 DTEs will be required to develop
and initiate a plan to use the DoD standard protocol architecture
and DDN standard X.25 service.

Use of DDN basic X.25 service imposes some restrictions on
the nature of the network communications service that a host can
obtain. These restrictions are discussed in Appendix A, Section
A-4.

1.2 Compliance

1.2.1 Compliance with CCITT X.25 and FIPS 100/Fed. Std. 1041

The DDN X.25 Interface Specification is compliant with CCITT Recommendation X.25 and FIPS 100/Fed. Std. 1041. The DDN X.25 DCE supports all facilities specified as E (essential) by FIPS 100/Fed. Std. 1041, and most facilities specified as A (additional). The additional facilities not supported are:

(i)   datagrams and associated facilities, and
(ii) bilateral closed user groups.

In that FIPS 100/Fed. Std. 1041 describes features for a DCE, DDN X.25 DTEs may support any or all facilities specified as either E or A by FIPS 100/Fed Std. 1041. However, DDN X.25 DTEs must not use the facilities identified above that are not supported by the DDN X.25 DCE.

1.2.2 DTE Compliance with This Specification

This document specifies several areas in which the DDN X.25 DCE is capable of operating in several modes. For example, Section 2.4 lists a number of signaling rates supported by the DCE. In such cases, a DDN X.25 DTE must implement at least one of the options listed (or the set of options required of a DTE by FIPS 100/Fed. Std. 1041) but need not implement all of the options listed (unless required by FIPS 100/Fed. Std. 1041). Determining the adequacy of the options supported by a DTE vendor for meeting a DDN subscriber's requirements is the responsibility of the subscriber.

In addition to the CCITT X.25 and FIPS 100/Fed. Std. 1041 requirements described in Section 1.2.1 above, DDN X.25 DTEs may wish to take advantage of additional DDN-specific features that are compatible extensions to the public standards. Implementation of a DDN-specific feature by a host is required only if the host wishes to take advantage of the service or information provided by the feature. For example, a host that wishes to establish calls only at the default precedence level assigned to it need not implement the precedence facility described in Section 2.1.2.2. However, a host that wishes to have flexibility in the precedence of the calls it establishes must implement this facility.

Any deficiencies with respect to this specification in a vendor-supplied X.25 DTE implementation contemplated for use with the DDN X.25 DCE should be rectified so as to attain compliance with this specification. Proper operation with DDN of an X.25 DTE that is not compliant with this specification cannot be guaranteed and should not be attempted. To this end, a test program is available through the Administration.

2   INTERFACE SPECIFICATION

2.1   Call Establishment Conventions

This section specifies DDN X.25 call establishment conventions.

2.1.1   Addressing

DDN addresses are assigned to subscriber DTEs by the Administration. Two basic forms of address are provided: physical addresses, which correspond to the node number and DCE port number of the node to which the DTE is connected, and logical addresses, which are mapped transparently by DCE software into a corresponding physical network address. Each DTE is assigned one physical address, and may be assigned one or more logical addresses. All DDN addresses are either twelve or fourteen BCD (binary-coded decimal) digits in length. A calling DTE need not determine whether a given address is a physical or logical address, in order to establish a call to that address.

2.1.1.1   Address Formats and Fields

DDN addresses have the following format:

$$ZZZZ \ F \ DDDDDDD \ (SS)$$

The various fields of the address are presented in Table 2.1 and are explained below.

Field	Meaning	Length (BCD digits)
ZZZZ	Reserved (must be zero)	4
F	Flag	1
DDDDDDD	DDN Host Identifier	7
(SS)	Sub-address (optional)	0 or 2
	TOTAL	12 or 14

Table 2.1 DDN X.25 Address Fields

2.1.1.1.1 Reserved

The Reserved field corresponds to the DNIC field generally used in public data networks. Pending assignment of a DDN DNIC, this field must be zero.

2.1.1.1.2 Flag

The Flag field is used to differentiate physical and logical addressing. The value zero indicates physical addressing, while the value one indicates logical addressing. A value of nine is used in the setup of calls to enable and disable logical addresses; see Appendix A, Section A-3.3.1.

2.1.1.1.3 DDN Host Identifier

The DDN Host Identifier is a seven-digit address, either logical or physical, assigned to a subscriber DTE by the DDN Administration.

2.1.1.1.4 Sub-Address

The Sub-Address may be used by a DTE for any purpose. It is carried across the network without modification. Its presence is optional.

2.1.1.2 Supplying Missing Address Information

The DDN X.25 DCE incorporates a mechanism to supply "missing" address information in CALL REQUEST and CALL ACCEPTED packets received from an attached DTE. This mechanism is useful in DTE software testing and physical address determination.

If a DTE sends a CALL REQUEST packet with no calling address field, the local DCE will insert the physical calling DDN Host Identifier with no subaddress field. If a DTE sends a CALL REQUEST or CALL ACCEPTED packet with either or both calling or called addresses that contain F = zero and DDDDDDD = zero, the local DCE will replace the DDN Host Identifier field (DDDDDDD) with the physical address of the DTE.

DTE implementors are cautioned that use of this mechanism in accepting calls to a DTE's logical address (See Appendix A, Section A-3.3) can result in confusion on the part of the calling DTE and is not advised.

2.1.2 DDN-Specific Facilities

Two DDN-specific features are requested by means of "private" or non-CCITT facilities in CALL REQUEST and CALL ACCEPTED packets. If either or both of these facilities are requested in a CALL REQUEST or CALL ACCEPTED packet, they must follow all CCITT X.25 facilities and must be preceded by a single facility marker, two octets of zero.

2.1.2.1 Type of Service Selection

The DDN X.25 provides two types of service, DDN basic X.25 service and DDN standard X.25 service. DDN standard X.25 service provides only local DTE to local DCE support of the X.25 connection. Data is carried via the network to its destination (using protocols internal to the network), where it is delivered using the access protocol of the destination host (i.e., either 1822 or DDN standard X.25 service). This access method is oriented towards DDN X.25 hosts using the DOD standard TCP/IP higher level protocols. No X.25 procedures change when using DDN standard X.25 service; however, the significance of the procedures changes (see Appendix A, Section A-3.2). There is no end-to-end X.25-level acknowledgement or guarantee of delivery of data packets with DDN standard X.25 service; reliability of DDN standard X.25 service is provided instead by the use of a reliable transport protocol.

DDN basic X.25 service provides end-to-end call management with significance as described in CCITT Recommendation X.25 and FIPS 100/Fed. Std. 1041. This access method is oriented towards hosts that have existing higher level protocol implementations that require reliable packet delivery at the network level.

Selection of DDN standard or DDN basic X.25 service must be made on a call-by-call basis by the DDN X.25 DTE at the time of call setup. To specify DDN standard X.25 service, a DTE must include in the CALL REQUEST packet a facility two octets long, coded as follows:

00000100 00000001

If this facility is not specified, DDN basic X.25 service will be provided.

2.1.2.2 Call Precedence

The precedence of a call is negotiated by an X.25 DTE by means of a facility two octets long, coded as:

00001000 000000XX

where XX is the precedence, from 0 (lowest precedence) to 3 (highest precedence). If this facility is not used, the call will be established at the subscriber's default precedence.

A DTE is not permitted to establish a call at a precedence level higher than that authorized for that DTE by the Administration. An attempt to do so will result in the DDN X.25 DCE returning to the DTE a CLEAR INDICATION packet with clearing cause 00001001, "Out of order," with diagnostic code 194, "Requested precedence too high."

Calls of a lower precedence may be cleared by a DCE if DCE or other network resources are required, or if access to the local or remote DTE is required (for a call of higher precedence). In this event, a CLEAR INDICATION packet will be sent with the clearing cause 00000101, "Network congestion," and with a diagnostic code specifying the reason for the preemption. The diagnostic codes employed for this purpose are 192, "Cleared due to higher precedence call at local DCE," and 193, "Cleared due to higher precedence call at remote DCE." Similarly, an attempt to establish a call may be unsuccessful if network resources are engaged in calls of higher priority than that requested. In this case, a CLEAR INDICATION packet will be sent with the clearing cause 00001001, "Out of order," and with either diagnostic code 192 or 193, as appropriate.

The diagnostic codes described in the preceding paragraphs are DDN-specific diagnostic codes; additional information about these codes may be found in Appendix A, Section A-3.1.

2.1.3 Protocol Identification

X.25 DTEs employing the DoD standard TCP/IP protocol architecture must indicate this by means of the call user data field of the CALL REQUEST packet. The first octet of this field must be set to 11001100 to identify the DoD standard protocol architecture.

Indication of the use of the DoD standard protocol architecture is independent of the selection of DDN standard or DDN basic X.25 service by means of the facility specified in Section 2.1.2.1 above. Therefore, a host employing the DoD standard protocol architecture and using DDN standard X.25 service must include both the DDN standard X.25 service facility and the call user data DoD standard protocol identification in its CALL REQUEST packet.

A DTE using a protocol architecture other than the standard DoD protocol architecture is free to use any call user data protocol identification recognized by the DTEs with which it wishes to communicate. Identification of protocol architectures other than the DoD standard architecture is not standardized or enforced by the Administration. Subscribers are cautioned, therefore, that conflicts among various vendor-assigned protocol identifications may arise.

2.1.4 Logical Channel Assignment

The assignment of logical channels by the DDN X.25 DCE follows the requirements and guidelines of FIPS 100/Fed. Std. 1041 and Annex A of CCITT X.25. Within the guidelines of CCITT X.25 Annex A, the range of logical channel numbers assigned to permanent virtual circuits, incoming, two-way, and outgoing virtual calls for DDN DCEs is configured for each DTE attached to a DCE by the Administration.

DDN X.25 DTEs must follow the logical channel selection requirements of FIPS 100/Fed. Std. 1041.

The number of logical channels available to a DTE is dependent upon the configuration of the DCE to which the DTE is attached, and upon the dynamic requirements placed upon other DCEs that share the same DDN packet switching node.

2.2 Packet Level Procedures

DDN X.25 packet level procedures are as specified by FIPS 100/Fed. Std. 1041 and CCITT X.25. The following additional information is provided:

1. The maximum window size that may be negotiated is seven.

2. Modulo 128 packet level sequence numbering is not supported.

3. Maximum packet sizes of 16, 32, 64, 128, 256, 512, and 1024 octets may be negotiated.

4. The DDN X.25 DCE uses additional packet level diagnostic codes, specified in Appendix A, Table A-1. DDN X.25 DTEs may, but are not required to, make use of the information conveyed by these codes.

5. The Qualifier bit (Q-bit) is passed transparently by the DDN X.25 DCE in DDN basic X.25 service. DTEs using DDN basic X.25 service may use the Q-bit in any way that is consistent with FIPS 100/Fed. Std. 1041.

6. The DDN X.25 DCE implements the diagnostic packet. It is sent under conditions specified in Annex D of CCITT X.25. The DTE is not required to act on the information provided in diagnostic packets.

7. DTEs using DDN standard X.25 service must restrict the maximum number of data bits in a complete packet sequence to be no more than 8056. This ensures that the data from a packet sequence transmitted by an X.25 host will fit within the maximum 1822 message length limit upon delivery to an 1822 host. This restriction is necessary as existing 1822 host implementations are not required to accept messages longer than 8063 bits. *

---

* DTEs using DDN standard X.25 service will generally be transmitting Internet Protocol datagrams, the length of which, by convention, does not approach this limit. Therefore, unless a protocol other than the Internet Protocol is used with DDN standard X.25 service, this is a technical restriction that will have no practical impact upon the design of DTE software. See Appendix A, Section 4-3.2.

DDN X.25 DTEs connecting to DDN through an X.25
Internet Private Line Interface (IPLI) must reduce
the maximum complete packet sequence length by an
additional 256 bits to allow for IPLI overhead.

2.3   Link Level Procedures

DDN X.25 link level procedures are as specified by FIPS
100/Fed. Std. 1041 and CCITT X.25. This section presents
additional information.

2.3.1   Link Level Parameters and Options

1. The default value of K, the maximum number of
    sequentially numbered I frames that the DCE will
    have outstanding (unacknowledged) at any given
    time, is seven. A DDN X.25 DCE may be configured
    on a per-DTE basis to provide optional values of K
    from one to six.

2. The default value of N2, the maximum number of
    transmissions and retransmissions of a frame
    following the expiration of the T1 timer, is
    twenty. This value can be changed to any value
    from one to 200 as a DCE configuration parameter
    on a per-DTE basis.

3. The optional 32-bit FCS is not supported.

2.3.2   Timer T1 and Parameter T2

The period of the timer T1 used by the DDN X.25 DCE reflects
assumptions about the processing speed of the DTE. The DCE
assumes that parameter T2, the response latency of the DTE to a
frame from the DCE, is no greater than 1/2 second. Likewise, the
DCE guarantees that its parameter T2, the latency in responding
to frames from the DTE, is 1/2 second for signaling rates of 19.2
kb/s or slower, and 1/4 second for faster links.

A lower bound for timer T1 may be computed to be 4X + T2,
based on the assumptions that:

  * the link propagation time is negligible,

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* the worst-case frame transmission time is X,

* timer T1 is started when a frame is scheduled for output. _____

* each frame is scheduled just as transmission of the previous frame starts,

* frames are not aborted. and

* each frame and its predecessor are of maximum length $N1 = 8248$ bits (see Section 2.3.3 below).

As an example, for a signaling rate of 9.6 Kb/s, this yields $X = .66$ sec. If T2 is .5 sec., the total time for the DTE to respond in the worst case should be 3.9 seconds. In fact, the DCE uses a T1 timer value of 4 seconds for a link speed of 9.6 Kb/s.

In no case does the DCE use a value for T1 smaller than 3 seconds. This means that, for faster links, the DTE's T2 parameter may be lengthened because the X term in the above formula is smaller. For links of 19.2 Kb/s or faster, DTEs are expected to satisfy latency requirements that allow the DCE to use the formula $4X + T2 \text{ (DTE)} < 3 \text{ seconds} = T1 \text{ (DCE)}$.

The DTE may choose any value for T1 that is compatible with the DCE's T2 parameter values. The value of T1 used by the DTE may always be set longer than the formula indicates, with the result that recovery from certain types of link errors will be slower. However, the DCE's parameter T2 cannot be reduced, so the formula should be viewed as yielding a lower bound on the DTE's T1 timer.

2.3.3 Maximum I Frame Size

The maximum number N1 of bits in an I Frame is 8248, accommodating a data packet with up to 1024 data octets. The derivation of this number is shown in Table 2.2.

DTEs using DDN standard X.25 service must observe the restriction on the number of data bits in a complete packet sequence given in Section 2.2 above.

| | X.25 | No. of |
Field Name	Level	Bits
Address	2	8
Control	2	8
General Format Identifier	3	4
Logical Channel Number	3	12
Packet Type	3	8
User Data	3	8192 (max)
Frame Check Sequence	2	16
TOTAL		8248 (max)

Table 2.2 Derivation of Maximum I Frame Size

2.4 Physical Level Specifications

The DDN X.25 physical level specification is in conformance
with FIPS 100/Fed. Std. 1041 and CCITT X.25. This section
presents additional information.

A DDN X.25 DTE may either be collocated with its DCE or may
be connected to it via an access line. In all cases the DTE
presents a physical DTE interface; the DDN will supply the
matching DCE interface. DDN X.25 service offers four physical
level interfaces: RS-232-C (CCITT V.28), RS-449, both balanced
and unbalanced (CCITT V.11 and V.10, respectively; also MIL-188-
114 balanced and unbalanced), and CCITT V.35. Appendix 8 of this
document describes in detail the choices of physical interface
available to the DDN subscriber and the specifications for each
type of interface. Table 2.3, below, summarizes the physical
interfaces available at each data rate supported by the DDN X.25
DCE, and indicates which interfaces are recommended at each
signaling rate.

A DDN X.25 DTE may implement any or all of the signaling
rates shown. At each signaling rate implemented, the DTE must
offer at least one of the physical interface options listed as
"R" (recommended) or "A" (available) for that rate in Table 2.3.
Implementors are encouraged to offer the widest variety of
signaling rates and physical interfaces practical to maximize the
ease of use of their equipment in DDN.

Physical Interface	Signaling Rate in Kb/s									
	1.2	2.4	4.8	9.6	14.4	48	50	56	64	100
RS-232-C	R	R	R	R	R	-	-	-	-	-
RS-449 unbal. (and equiv.)	A	A	A	A	-	-	-	-	-	-
RS-449 balanced (and equiv.)	A	A	A	A	A	A	A	A	A	R
CCITT V.35	-	-	-	-	-	R	A	R	R	A

Legend

R = Recommended
A = Available
- = Not available

(Taken from Appendix B, Table B-4

Table 2.3 DDN X.25 Physical Signaling Rates and Interfaces

3 BIBLIOGRAPHY

1. "Specification for the Interconnection of a Host and an IMP," Report No. 1822. Bolt Beranek and Newman Inc., Cambridge, MA. revision of December 1981.

2. CCITT Recommendation X.25, "Interface Between Data Terminal Equipment (DTE) and Data Circuit Terminating Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks." International Telegraph and Telephone Consultative Committee Yellow Book. Vol. VIII.2, Geneva, 1981.

3. "Defense Data Network Subscriber Interface Guide," Defense Communications Agency, Washington, DC. July 1983.

4. "Internet Protocol Transition Workbook." SRI International, Menlo Park, CA. March 1982.

5. "Internet Protocol Implementation Guide." SRI International, Menlo Park, CA, August 1982.

APPENDIX A: DDN X.25 Implementation Details

A-1   Introduction

     This Appendix serves three purposes. First, it provides
information concerning the planned evolution of DDN X.25
capabilities. Second, it provides information on the use of
certain DDN X.25 features and facilities at a greater level of
detail than is appropriate for inclusion in the body of the DDN
X.25 Interface Specification. Specifications for the use of DDN
X.25 features and facilities given in this Appendix are mandatory
on the part of DDN X.25 DTEs that wish to make use of these
features and facilities. Finally, this Appendix presents a
discussion of the limitations on the use of DDN services that
will be encountered by hosts using only DDN basic X.25 service.

A-2   Operational Features of DDN X.25 DCE Releases

     The capabilities of the DDN X.25 DCE will evolve over time
from an initial set of capabilities to the full capabilities of
this DDN X.25 Interface Specification.   This section describes
release-dependent features of the DDN X.25 DCE. Implementors
should note that not all optional facilities of the specification
will initially be available for use by DTEs.

     Releases of new DCE capabilities will be compatible with DTE
hardware and software implementations that meet the full DDN X.25
Interface Specification.

A-2.1   Initial Feature Support

     The initial release of the DDN X.25 DCE will support flow
control parameter negotiation and fast select. In addition, the
DDN X.25 DCE may be configured by the DDN Administration to
provide non-standard default window and packet sizes as described
in CCITT X.25 Sections 7.1.2 and 7.2.1. The call precedence and
type of service selection facilities will be accepted, but not
acted upon, by the network. Only DDN basic X.25 service will be
supported.   Planned future DCE releases will support all
facilities specified in FIPS 100/Federal Standard 1041 with the
exception of those "additional" facilities that are listed in
Section 1.2.1 of this document.

A detailed schedule of DDN X.25 DCE releases and the
capabilities of each release will be supplied in a separate
document.

A-2.2 Exception-handling Procedures

Certain of the exception- or error-handling procedures of
the initial release of the DDN X.25 DCE differ in detail from the
procedures specified in FIPS 100/Federal Standard 1041. These
differences are described below. A later release of the DDN X.25
DCE will bring these procedures into conformance. In the
interim, the variances in these procedures will not preclude
satisfactory operation between the DCE and a DTE, provided the
DTE operates in accordance with FIPS 100/Federal Standard 1041.

A-2.2.1   Non-Octet-Aligned Data

Data packets received by the DDN X.25 DCE that are not
aligned on an octet boundary are discarded at the link level.
They are not passed to the DCE packet level, and no packet level
diagnostic code is returned to the DTE.

A-2.2.2   RESTART REQUEST Packet

The DDN X.25 DCE will not discard, but will instead act
upon, a RESTART REQUEST packet that

   (i) is too long (unless it exceeds the maximum frame
        size for the link level),

        or

   (ii) contains a non-zero cause field.

A-2.2.3   RESET REQUEST Packet

The DDN X.25 DCE will not discard, but will instead act
upon, a RESET REQUEST packet that contains a non-zero reset cause
field.

A-2.2.4   CLEAR REQUEST Packet

The DDN X.25 DCE will not discard, but will instead act upon, a CLEAR REQUEST packet that contains a non-zero clearing cause field.

A-2.3   Virtual Circuit Resource Availability

In its current implementation, the DDN X.25 packet switching node is capable of supporting a minimum of one hundred simultaneous virtual circuits. As was discussed in Section 2.1.4, resources of the node are shared dynamically among the DCEs attached to the node. Therefore, no explicit guarantees are made of the number of simultaneous virtual circuits that can be made by a single DTE. Depending upon the configuration of the node, the number of simultaneous circuits supported by the node can be significantly greater than one hundred.

A-3   Detailed Features and Facilities Specifications

This section provides detailed specifications and descriptions of use for certain DDN X.25 features and facilities.

A-3.1   Additional Diagnostic Codes

The DDN X.25 DCE is capable of providing additional information to DTEs in RESTART, RESET, CLEAR INDICATION, and DIAGNOSTIC packets by means of diagnostic codes that are extensions to the set of diagnostic codes given in Annex E of CCITT Recommendation X.25. These codes are taken from the set of codes "reserved for network specific diagnostic information," and are thus not in conflict with code assignments made in Annex E. The values of these codes, and their meanings, are given in Table A-1 below.

```
Coae
value  meaning

    128  IMP  is  unavailable.  The  packet-forwarding
         mechanisms  of  the  network  are  unavailable  to  the
         DCE.  Sent  in  RESET,  CLEAR  and  RESTART  packets.

    130  Link  level  came  up.  Sent  in  RESTART  and  RESET
         packets.

    131  Link  level  went  down  at  remote  DTE.  Sent  in  CLEAR
         and  RESET  packets.

    132  Remote  DTE  restarted.  Sent  in  CLEAR  and  RESET
         packets.

    133  Local  resources  not  available  for  call
         establishment.  The  local  DCE  has  too  few
         resources  to  establish  another  call.  Sent  in
         CLEAR  and  DIAGNOSTIC  packets.

    134  Remote  resources  not  available  for  call
         establishment.  The  remote  DCE  has  too  few
         resources  to  establish  another  call.  Sent  in
         CLEAR  packets.

    136  Remote  host  dead.  The  link  to  the  remote  DTE  is
         down.  Sent  in  CLEAR  and  RESET  packets.

    137  Remote  IMP  dead.  The  IMP  to  which  the  remote  DTE
         is  attached  is  down.  Sent  in  CLEAR  and  RESET
         packets.

    138  Logical  subnetwork  access  barred.  The  remote  DTE
         cannot  be  reached  because  of  a  communities-of-
         interest  prohibition.  Sent  in  CLEAR  and  RESET
         packets.

    139  Connection  lost.  An  internal  error  has  occurred
         at  either  the  remote  or  the  local  DCE  which  has
         made  their  virtual  circuit  data  structures
         inconsistent.  Sent  in  CLEAR  and  RESET  packets.

    140  Response  lost.  A  response  from  the  remote  DCE
         failed  to  arrive  within  a  reasonable  time.  Sent
         in  CLEAR  and  RESET  packets.
```

141 Calling logical address not enabled or not authorized. Sent in CLEAR packets.

142 Calling logical name incorrect for this DTE. Sent in CLEAR packets.

143 Called logical name not authorized. Sent in CLEAR packets.

144 Called logical name not enabled. Sent in CLEAR packets.

145 Called logical name has no enabled DTEs. Sent in CLEAR packets.

146 Use of logical addresses invalid in this network. Sent in CLEAR packets.

147 Declared logical name now in effect. Sent in CLEAR packets.

148 Declared logical name was already in effect. Sent in CLEAR packets.

149 Declared logical name is now disabled. Sent in CLEAR packets.

150 Declared logical name was already disabled. Sent in CLEAR packets.

151 Incoming calls barred. Sent in CLEAR packets.

152 Outgoing calls barred. Sent in CLEAR packets.

192 Cleared due to higher precedence call at local DCE. Sent in CLEAR packets.

193 Cleared due to higher precedence call at remote DCE. Sent in CLEAR packets.

194 Requested precedence too high. The DTE is not authorized to establish a call at the requested precedence level. Sent in CLEAR packets.

Table A-1. Additional Packet Level Diagnostic Codes

A-5

A-3.2 X.25 IP Interoperability Considerations

When DDN standard X.25 service is requested at call
establishment (as described in Section 2.1.2.1), the call is in
effect established between the DTE and a local X.25 entity. This
entity subsequently extracts the IP datagrams from the X.25 data
packets for transmission through the DDN Internet. This approach
requires that certain conventions be followed:

1. IP datagrams are to be sent as X.25 complete
   packet sequences. That is, datagrams begin on
   packet boundaries and the M ("more data") bit is
   used for datagrams that are larger than one
   packet. Only one IP datagram is to be sent per
   X.25 complete packet sequence.

2. By convention, the maximum IP datagram size is 576
   octets. This packet size can most efficiently be
   accommodated by negotiating an X.25 maximum packet
   size of 1024; alternatively, a DTE may use an X.25
   complete packet sequence to transmit an IP
   datagram.

3. Because the X.25 connection is in effect
   terminated locally, the D and Q bits have no
   significance and should be set to zero.

4. The precedence bits of the IP type-of-service
   field are to be mapped into X.25 precedence bits
   (see Section 2.1.2.2) as specified in Table A-2.

IP Precedence	X.25 Precedence
000	00
001	01
010	10
011 - 111	11

Table A-2. IP Precedence to X.25 Precedence Mapping

A-3.3 The DDN Logical Addressing Facility

The DDN logical addressing facility allows references to hosts by either their physical network address or by one or more location-independent logical addresses, and allows hosts to exercise partial control over the logical address(es) by which they can be referenced. Implementation of DDN logical addressing by a host is optional.

The DDN Administration will assign seven-digit logical addresses, and will maintain a logical addressing data base. The host is then responsible for notifying the network ("enabling") of the "names" (logical addresses), if any, by which it wishes to be known. It cannot receive calls addressed to a name or originate calls under that name unless it has enabled that name. It also cannot enable a name that is not authorized for that physical address. Names can also be enabled automatically by the network, under the control of the Administration.

A-3.3.1 Logical Addresses

Logical addressing is invoked when a called address is supplied to the IMP with the flag digit F = one. The logical address consists of seven BCD digits. This name is mapped by the logical addressing facility into a DDN physical network address. The logical name need not be unique for the physical address, nor is the physical address necessarily unique for the name.

A-3.3.2 Enabling and Disabling Logical Addresses

To enable and disable logical addresses, the DDN X.25 host must send declarative CALL REQUEST packets to the DCE using a called address with the format:

ZZZZ F DDDDDDD (SS)

where the address fields are as described in Section 2.1.1. The Flag F must be set to nine. the DDN Host Identifier field specifies the logical address under consideration, and the subaddress field, which must be present, specifies the type of transaction. Declarative calls are cleared immediately by the local DCE.

If SS is zero, the logical name is enabled in normal mode;
that is, that physical port will accept incoming calls to that
name, and allow outgoing calls from that name. If SS is one, the
logical name is disabled. If SS is two, the logical address is
enabled in reverse translation mode; in this mode, the called
address field of incoming call packets will be translated into a
physical address (i.e., an address containing a flag F = 0), if
it was given by the calling DTE (X.25 host), as a logical address
(i.e., containing a flag F = 1).

Whenever a DTE comes up, or restarts, the logical names for
that DTE are returned to their default state, which may be either
enabled or disabled, as configured by the DDN Administration.

A-4   Limitations of DDN Basic X.25 Service

The Defense Data Network is an Internetwork environment.
That is, DDN as a whole is made up of a number of constituent
packet switching networks that are interconnected via gateways.
Communication across gateways requires the use of the Internet
Protocol, which, for a host accessing DDN using X.25, requires
that the host implement the DoD standard protocol architecture
and employ DDN standard X.25 service. In addition, a classified
host is attached to a DDN constituent network of lower
classification by means of an Internet Private Line Interface
(IPLI). IPLIs, which themselves contain gateways, also require
the use of the Internet Protocol; moreover, they do not, as
currently designed, offer an X.25 host interface. These
attributes of the DDN Internet have two implications for users of
DDN basic X.25 service:

   1.   DDN hosts that do not implement IP and higher-
        level DDN protocols, and which use only DDN basic
        X.25 service, cannot communicate across gateways.
        Their network communication is therefore
        restricted to a single DDN constituent network.

   2.   X.25 hosts cannot be provided classified service
        on a constituent network of lower classification.
        Should X.25 host access be developed for the IPLI
        in the future, classified network access will be
        made available to hosts using DDN standard X.25
        service only.

A-5 Derivation of DDN X.25 Addresses

All DDN hosts are assigned addresses by the Administration.
The address of a DDN host may be obtained from the Network
Information Center (NIC), represented as an ASCII text string in
what is called "host table format." This section describes the
process by which DDN X.25 addresses in the format described in
Section 2.1.1 may be derived from addresses in NIC host table
format.

A NIC host table address consists of the ASCII text string
representations of four decimal numbers separated by periods,
corresponding to the four octets of a thirty-two bit Internet
address. The four decimal numbers are referred to in this
section as "n", "h", "l", and "i". Thus, a host table address
may be represented as "n.n.l.i". Each of these four numbers will
have either one, two, or three decimal digits and will never have
a value greater than 255. For example, in the host table address
"10.2.0.124", n=10, n=2, l=0, and i=124. To convert a host table
address to a DDN X.25 address:

1. If h < 64, the host table address corresponds to
    the DDN X.25 physical address

              ZZZZ F IIIHHZZ.(SS)

where:

        ZZZZ = 0000
                as required in Section 2.1.1.1.1;

        F = 0   because the address is a physical
                address;

        III   is a three decimal digit
                representation of "i", right-adjusted
                and padded with leading zeros if
                required;

        HH   is a two decimal digit representation
                of "h", right-adjusted and padded
                with leading zeros if required;

        ZZ = 00
                and

        (SS)   is optional, as described in Section
                2.1.1.1.4.

In the example given above, the host table address 10.2.0.124 corresponds to the DDN X.25 physical address 000001240200.

2. If n > 64 or n = 64, the host table address corresponds to the DDN X.25 logical address

$$ZZZZ \ F \ RRRRRZZ \ (SS)$$

where:

ZZZZ = 0000
as required in Section 2.1.1.1.1;

F = 1   because the address is a logical address;

RRRRR   is a five decimal digit representation of the result "r" of the calculation

$$r = n * 256 + 1$$

(note that the decimal representation of "r" will always require five digits);

ZZ = 00
and

(SS)   is optional, as described in Section 2.1.1.1.4.

Thus, the host table address 10.83.0.207 corresponds to the DDN X.25 logical address 000012145500.

In both cases, the "n" and "l" fields of the host table address are not used.

APPENDIX B: DDN Synchronous Level 1 Specification

B-1   Introduction

A host may connect to the Defense Data Network at the link
level using the asynchronous bit serial protocol described in BBN
Report No. 1822 as either a local host (LH) or a distant host
(DH). A host may also connect to the DDN by means of a
synchronous bit serial protocol at the link level, using either
the method described in BBN Report No. 1822, HDH, or the DDN X.25
interface. Neither LH nor DH is recommended for new
implementations.

This section describes the functional, electrical, and
mechanical connection (the level 1 connection) that is required
when either an HDH or an X.25 host is connected to the DDN.
Hosts connecting to the DDN via HDH or X.25 require a synchronous
modem connection or the equivalent, which will be supplied as
part of the DDN service. The host will present the DTE interface
while the DDN-provided equipment will present the DCE interface.

A long-term goal of the DDN is for all level 1 connections
to be accomplished with the MIL-188-114 balanced interface. Its
general equivalents are EIA RS-449/422, CCITT V.11, and Fed. Std.
1031/1020. The DDN cannot implement this at present due to the
limited availability of commercial vendor hardware. In order to
facilitate future DDN compatibility, all new system acquisitions
should specify MIL-188-114 balanced as a required interface, in
addition to an alternate interface. The selection of an
alternate interface should not preclude utilization of the MIL-
188-114 balanced interface when it becomes supportable.

B-2   Supported Interfaces

DDN presently supports four synchronous level 1 interfaces.
They are:

   1. EIA RS-232-C, CCITT V.28 & V.24;

   2. MIL-188-114 balanced, EIA RS-449&422, CCITT V.11,
       Fed. Std. 1031/1020;

   3. MIL-188-114 unbalanced, EIA RS-449&423,   CCITT
       V.10, Fed. Std. 1031/1030; and

4. CCITT V.35.

Table B-1 is a dictionary of terms that relates the CCITT signal ID to the EIA signal ID and to the more common abbreviations. Table B-2 identifies signals as either required, optional, or not used.

Figure B-1 and Table B-3 identify typical DTE connections to the DDN. The required subscriber services will dictate which scheme is selected for a particular DTE.

Table B-4 relates required speed of service to interface type.

Together, these tables and figures serve as a guide to level 1 interface selection. From these, most systems will be able to identify the most appropriate interface. However, this information is not all-inclusive. Other interface arrangements may be possible; contact your DDN representative for assistance as required.

                    Demarcation Point
                    (mating connectors)

                DTE   DCE

        |-------------] [------(1) Modem   RS-232-C
        |
        | |----------] [------(2) Modem   V.35
     |---|--|----|
        | |----] [------(3) LDM   RS-232-C, MIL-188-114
        | |
        | |----] [------(4) Null Modem Cable
        | |
        | HOST |----] [------(5) SME   Cable plus clock source
        | |
        | |----] [------(6) DCS   MIL-188-114
     |--|--|--|--|
        | | |-------] [------(7) DES   RS-232-C, RS-449, V.35
        | |
        | |-----------] [------(8) KG   MIL-188-114 balanced
        |
        |--------------] [------(9) IPLI   MIL-188-114 balanced
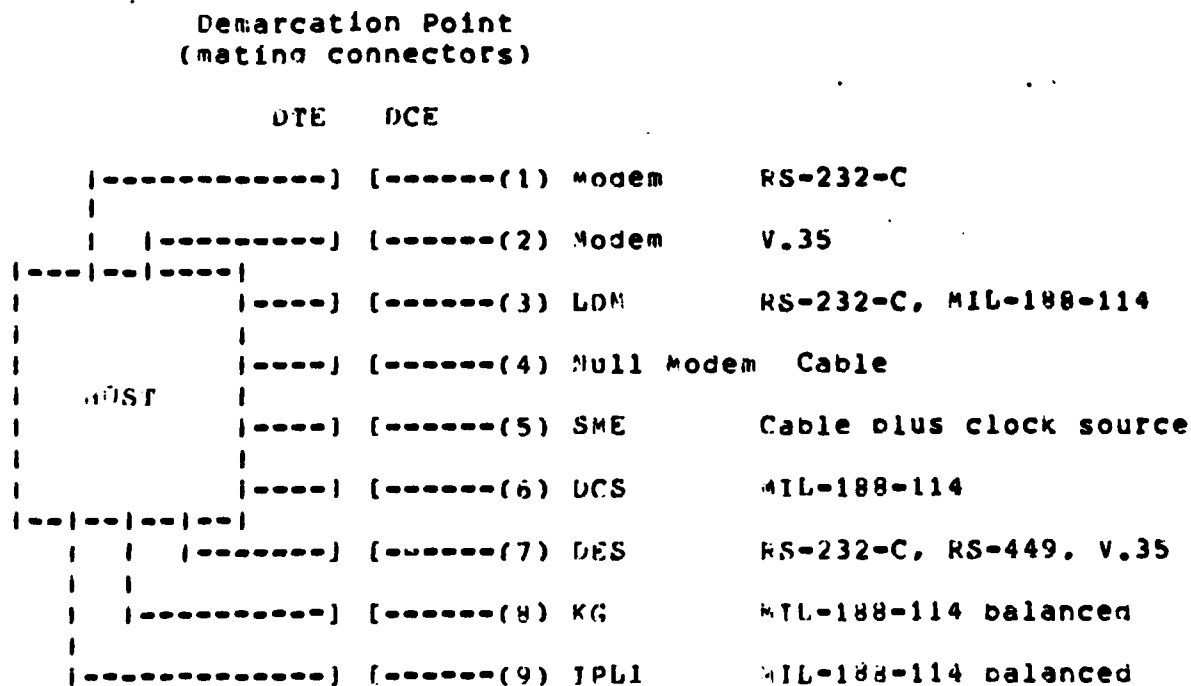
            Figure B-1. Typical Level 1 Connection Schemes

                                B-2

EIA ID	CCITT ID	ABBREV NAME	NAME
AA	101	FG	Frame (Chassis/Protective) Ground
AB	102	SG	Signal/Supply Common
SC	102a	--	RS-449 DTE Common
RC	102b	--	RS-449 DCE Common
BA	103	TD	Transmit Data
BB	104	RD	Receive Data
CA	105	RTS	Request to Send
CB	106	CTS	Clear to Send
CC	107	DSR	Data Set Ready
CD	108.2	DTR	Data Terminal Ready
CF	109	DCD	Data Carrier Detect
CG	110	SQ	Signal Quality
CH	111	--	Signal Rate Selector to DCE
CI	112	--	Signal Rate Selector to DTE
DA	113	ETC	External Transmit Clock
DB	114	TC	Transmit Clock
DD	115	RC	Receive Clock
--	116	--	Select Standby
--	117	--	Standby Indicator
SBA	118	STD	Secondary Transmit Data
SBB	119	SRD	Secondary Receive Data
SCA	120	SRS	Secondary Request to Send
SCB	121	SCS	Secondary Clear to Send
SCF	122	SCD	Secondary Carrier Detect
SCG	123	SSQ	Secondary Signal Quality
--	124	--	Select Frequency Group
CE	125	RI	Ringing Indicator
--	126	--	Select Transmit Frequency
--	127	--	Select Receive Frequency
--	128	--	External Receive Clock
--	129	RR	Request to Receive
--	130	--	Secondary Transmit Tone
--	131	--	Receive Character Timing
--	132	--	Return to Non-Data Mode
--	133	RTR	Ready to Receive
--	134	--	Received Data Present
--	135	--	New Signal
--	140	RL	Remote Loopback
--	141	LL	Local Loopback
--	142	TM	Test Status Monitor
--	191	--	Transmit Voice Answer
--	192	--	Receive Voice Answer

Table A-1. EIA and CCITT Interchange Circuits

Required: 101, 102, 103, 104, 105, 106, 107, 108.2,
           109, 113, 114, and 115

Optional: 110, 125, 140, 141, ana 142
           (These may be required IAW future DDN
           developments; it is stronaly recommended
           that these at least be available for
           implementation upon requirement).

Not usea: 111, 112, 116, 117, 118, 119, 120, 121, 122,
           123, 124, 126, 127, 128, 129, 130, 131, 132,
           133, 134, 136, 191, and 192

Table B-2. Signal Selection by CCITT Interchange Circuit Number

Scheme (From
  Fig. 3-1)   Explanation

(1) Modem   RS-232 at speeds of 1200, 2400, 4800, 9600 or
                 14400 b/s over long haul leased voice grade
                 telephone facilities

(2) Modem   CCITT V.35 at speeds of 48, 50, 56, 64 Kb/s over
                 leased group (37KHz) grade facilities or in CONUS
                 the Digital Data Service facilities.

(3) Limited Distance Modem
                 LDM generally available at 9600 b/s and below in
                 an RS-232 version. Other types are available for
                 all speeds.

(4) Null Modem   A Null Modem is a length of cable with the signal
                 leads crossed so as to present a DCE interface.
                 To be used in local connection schemes where
                 either the DTE or the DCE has a clocking source
                 capability. All four supported level 1
                 interfaces are available. If DTE clock and DCE
                 clock are both available, DTE clock will be
                 preferred.

(5) Synchronous Modem Eliminator
                 SME is a length of cable with a hardware device
                 interjected. The device allows convenient
                 crossing of signals so as to present a DCE
                 interface. The device also provides clocking
                 when neither the DTE nor the DCE has such
                 capability. All four supported level 1
                 interfaces are available.

(6) DCS Microwave
                 DCS is generally a military microwave system
                 which provides the MIL-188-114 balanced or
                 unbalanced interfaces. It implies a speed of 50
                 Kbps and is usually found O-CONUS. Selection of
                 this scheme requires selection of (4) or (5).

(7) Data Encryption Standard
                 DES is a commercial encryption device used by the
                 DoD as a privacy device. DES is available with
                 either RS-232, V.35, or RS-449/422.

H-5

(8) KG   KG devices are U. S. Government encryption
                      devices under strict NSA control. The
                      requirement for security and KG devices requires
                      the selection of the MIL-188-114 balanced
                      interface.

(9) Internet Private Line Interface
                      IPLI devices are security level community of
                      interest isolation devices. The requirement for
                      IPLI service requires the selection of the MIL-
                      188-114 balanced interface.

    Notes and Considerations

1. Interface (2), Modem, 48Kb/s is generally only
    available O-CONUS.

2. MIL-188-114 balanced is deemed equivalent to RS-449
    with RS-422, the difference being that MIL-188-114 is
    more tolerant of noise on signal common and more
    tolerant of common mode noise.

3. MIL-188-114 unbalanced is deemed equivalent to RS-449
    with RS-423. In most cases where MIL-188-114 balanced
    is specified, MIL-188-114 unbalanced is also available,
    but it is not recommended.

4. There are system enhancements under long term
    development for use in the DDN which may request
    additional control leads beyond those listed as
    required. The implementation of these enhancements
    will not limit operational capabilities but may impact
    the ability of the Network Monitoring Center to assist
    with host and host access line diagnosis. These
    enhancements may request signals from the optional
    category.

                 Table 8-3. Typical Level 1 Connection Schemes

Signaling Rate in Kb/s

Physical Interface	1.2	2.4	4.8	9.6	14.4	48	50	56	64	100
RS-232-C	R	R	R	R	R*	-	-	-	-	-
MIL-188-114 unbal. (& equiv.)	A	A	A	A	-	-	-	-	-	-
MIL-188-114 bal. (& equiv.)	A	A	A	A	A*	A	A	A	A	R**
CCITT V.35	-	-	-	-	-	R	A	R	R	A

Legend

R = Recommended
A = Available
- = Not available
* = Only available using modems
** = Only available using a local cable connection

Table B-4. Interface Type by Service Speed

B-7

Signal Name	Abbrev	Pin No.	EIA ID	Signal Source
Frame Ground	FG	1	AA	DTE/DCE
Transmitted Data	TD	2	BA	DTE
Received Data	RD	3	BB	DCE
Request to Send	RTS	4	CA	DTE
Clear to Send	CTS	5	CB	DCE
Data Set Ready	DSR	6	CC	DCE
Signal Ground	SG	7	AB	DTE/DCE
Data Carrier Detect	DCD	8	CF	DCE
Transmit Clock	TC	15	DB	DCE
Receive Clock	RC	17	DD	DCE
Data Terminal Ready	DTR	20	CD	DTE
Ext. Transmit Clock	ETC	24	DA	DTE
Wired Spare	--	18	--	---
Wired Spare	--	22	--	---
Wired Spare	--	25	--	---

Required pins: 1, 2, 3, 4, 5, 6, 7, 8, 15, 17, 20, 24
Optional pins: 9, 10, 18, 22, 25

Notes:

1. The DTE will present a CANNON DB-25P male connector
   with pinouts as above or equivalent hardware with
   identical pinouts.

2. The DCE will present a CANNON DB-25S female
   connector or equivalent.

Table B-5. RS-232-C Interface

Signal Name	Abbrev	Pin Nos.	EIA ID	Signal Source
Send Data	SD	4,22	BA	DTE
Send Timing	ST	5,23	DB	DCE
Receive Data	RD	6,24	BB	DCE
Request to Send	RTS	7,25	CA	DTE
Receive Timing	RT	8,26	DD	DCE
Clear to Send	CTS	9,27	CB	DCE
Local Loopback	LL	10	--	DTE
Data Mode	DM	11,29	CC	DCE
Terminal Ready	TR	12,30	CD	DTE
Receiver Ready	RR	13,31	CF	DCE
Remote Loopback	RL	14	--	DTE
Terminal Timing	TT	17,35	DA	DTE
Test Mode	TM	18	--	DCE
Signal Ground	SG	19	AB	DTE/DCE
Receive Common	RC	20	RC	DCE
Send Common	SC	37	SC	DTE
Wired Spare	--	1	--	---
Wired Spare	--	3,21	--	---

Required pins: 4,22; 5,23; 6,24; 7,25; 8,26; 9,27;
                11,29; 12,30; 13,31; 17,35; 19; 20; 37
Optional pins: 10; 14; 18; 1; 3,21

Notes:

1. The DTE will present a CANNON DC-37P male connector
   with pinouts as above or equivalent hardware with
   identical pinout.

2. The DCE will present a CANNON DC-37S female
   connector or equivalent.

Table E-5. MIL-188-114 Interface (and equivalents)

Signal Name	Abbrev	Pin Nos.	EIA ID	Signal Source
Frame Ground	FG	A	AA	DTE/DCE
Signal Ground	SG	B	AB	DTE/DCE
Transmit Data	TD	P/S	BA	DTE
Receive Data	RD	R/T	BB	DCE
Request to Send	RTS	C	CA	DTE
Clear to Send	CTS	D	CB	DCE
Data Set Ready	DSR	E	CC	DCE
Data Carrier Detect	DCD	F	CF	DCE
Local Loopback	LL	K	--	DTE
Ext. Transmit Clock	ETC	U/W	DA	DTE
Transmit Clock	TC	Y/aa	DB	DCE
Receive Clock	RC	V/X	DD	DCE

Required Pins: A; B; P/S; R/T; C; D; E; F; U/W; Y/aa; V/X

Optional Pins: K

Notes:

1. The DTE will present a Winchester MRA(C)-34D-JTCH-H8 male connector with pinout as above or equivalent hardware with the identical pinout.

2. The DCE will present a mating female connector.

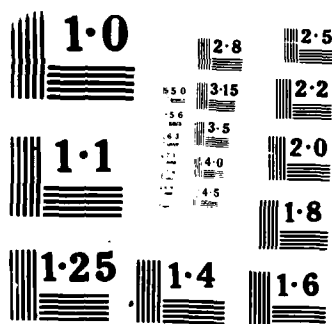Table 6-7. V.35 Interface

END

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DTIC

SUPPLEMENTARY

INFORMATION

Errata

AD-A137 427

Appendix C is available from
NTIS as FIPS-PUB-100

DTIC-FDAC
26 June 1986

END

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